Special Bulletin No. 147 May, 1925

CHERRY LEAF-SPOT

Residual Effects and Control

W. C. DUTTON AND H. M. WELLS

AGRICULTURAL EXPERIMENT STATION
MICHIGAN STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

HORTICULTURAL SECTION

East Lansing, Michigan

Cherry Leaf-Spot

Residual Effects and Control

W. C. DUTTON AND H. M. WELLS

Cherries in Michigan are subject to injury by several insects and diseases. The most serious of these are leaf-spot, brown-rot, and curculio; all these may be controlled by proper spraying. Leaf-spot offers the greatest difficulty in control and if not held in check it will cause more injury to the tree than either brown-rot or curculio. Proper spraying for leaf-spot generally controls the other troubles. It naturally follows, then, that the greatest emphasis should be placed on the control of leaf-spot.

THE NATURE AND DEVELOPMENT OF LEAF-SPOT

This disease is caused by a fungus known as *Coccomyces hiemalis;* it is also known by several common names as yellow-leaf, leaf-blight, shot-hole, etc., the name used varying somewhat with the way in which the leaf appears when affected by the fungus. Leaf-spot does not appear in epidemic form every year, as its natural development is controlled by climatic conditions. The fungus lives over the winter in the old leaves on the ground, and the primary or first infection on the new foliage in the early summer is caused by spores which are discharged from these old leaves. The development of these spores in the old leaves depends on proper conditions of moisture and temperature and their discharge occurs only after the leaves have been thoroughly saturated with water for several hours. When discharged they are carried to the new leaves by wind or air currents and there germinate and grow into the leaves, provided the leaves remain moist until this is accomplished. After the fungus has developed in the leaves, more spores, of another type are formed and they may cause further spread of the disease provided, again, that there is plenty of moisture present on the leaves.

The foregoing statements indicate that an epidemic of leaf-spot is likely to develop only during a wet or rainy season. Some years the amount and distribution of the rainfall is such that it causes little or no injury. This situation is, for some growers, rather unfortunate for it is indirectly responsible for serious losses during seasons when conditions favor leaf-spot development. The difficulty arises in this way; after two or three years without a leaf-spot epidemic, many growers become lax in their spraying operations, thinking that spraying is not necessary, or that it need not be done so thoroughly or so often. Consequently the next season that is favorable for serious spread of leaf-spot, finds the trees poorly protected. Growers who spray regularly and thoroughly every year seldom suffer any serious loss from this disease.

The leaf-spot fungus affects the leaves of the cherry and it is principally

through the loss of leaves that injury occurs. Other parts of the plant are occasionally affected, but the real danger is in the loss of foliage.

The Seriousness of Defoliation by Leaf-Spot. Injury and loss from cherry leaf-spot may develop immediately if defoliation occurs before the cherries are harvested. Trees that lose their leaves early in the season do not mature their fruit; it remains small and sour and does not color properly. Such fruit is unmarketable. This, of course, is a serious loss. Even more serious injury may result from defoliation by leaf-spot; namely, the complete loss of trees. This usually does not occur directly or immediately, but may be delayed until the following winter. If such trees survive the first winter their vigor is so lowered that they are more susceptible to injury in succeeding winters and may eventually succumb. More frequently the trees are not killed; in such instances the effects of the defoliation are spread out over the next and succeeding seasons. Such injury is rather difficult to measure exactly. As a matter of fact, the real seriousness of these holdover effects may not be realized unless there are trees nearby which were not defoliated to serve as a contrast with the weakened trees.

SOME HOLDOVER EFFECTS OF DEFOLIATION BY CHERRY LEAF-SPOT

For several years, spraying and dusting experiments with cherries were conducted in the Titus Brothers' orchard, four miles north of Traverse City on the Grand Traverse Peninsula. The variety was Montmorency and the trees were eleven years old. The soil is of the better type of sand. During the season of 1922, conditions were very favorable for the development of cherry leaf-spot. In these experiments, certain trees which were left unsprayed were almost completely defoliated by July 15. Another plot was sprayed with a material which was almost completely effective and no appreciable amount of defoliation occurred. The unsprayed trees were adjacent to the trees in the sprayed plot from which the records were obtained.

The trees were all sprayed uniformly in 1923. Lime-sulphur solution and lead arsenate were used, and there was no defoliation during 1923 from leaf-spot or spray injury. The cultivation was uniform for all trees. Observations were made in 1923 and 1924 to determine how this premature defoliation had affected the performance of the trees. The results of these observations are presented in the following paragraphs and tables.

On the Time of Blooming. The blossoms on defoliated trees* opened from two to four days later than on trees which were not defoliated.

On the Size of Fruit-Buds and Blossoms. The fruit buds on defoliated trees were relatively small and the flowers which they produced were much smaller than those on trees which had not been defoliated.

On the Number of Flowers, Set of Fruit, and Size of Cherries. In the first place, 18 per cent of the spurs on the defoliated trees died during the winter, while practically all survived on the trees that had retained their foliage. A comparison of the 82 per cent that lived through the winter on the defoliated trees with the spurs on normal trees is made in Table 1.* Similar data are presented in Table 2 for the flowers and fruit borne on shoots.

*The word "defoliation," as used in the following discussion, refers to the premature defoliation which occurred in June and July as the result of injury by leaf-spot.

*A rather arbitrary distinction has been made between spurs and shoots. All growth up to 1.5 centimeters in length is classed as "spurs" and any growth 1.6 centimeters or more in length as "shoots."

Table 1. The Holdover Effects of Premature Defoliation in 1922 on the Production of Flowers and Fruit on Spurs in 1923.

	Defoliated	Not Defoliated
Number of spurs for which records were obtained	132	133
Average number of fruit buds per spur, 1923	3.4	3.9
Average number of flowers per bud, 1923	2.0	3.2
Average number of flowers per spur, 1923	7.1	12.9
Percentage of flowers maturing fruit, 1923	22.0	25.0
Average number of cherries harvested per spur, 1923	1.5	3.2
Average weight per cherry (grams), 1923	2.9	3.3
Average weight of cherries per spur (grams), 1923	4.6	10.9

There was no great difference in the number of fruit buds per spur, and this is not surprising as the defoliation did not occur until after spur growth was complete and probably after fruit bud differentiation had occurred. This defoliation, however, was effective in checking the late summer and fall development of these buds, as is shown in the reduction by nearly a half of the number of flowers per spur. The percentage of flowers which matured fruit was only slightly less for the defoliated trees; but with fewer flowers at the start, the actual number of cherries per spur was much smaller —less than half as many, in fact, as on normal undefoliated trees. The size of the cherries on the defoliated trees was reduced about 12 per cent. The total production of fruit per spur, by weight, of such trees was only 42 per cent of that of normal trees. The comparative performance of shoots for the two classes of trees was, in a general way, about the same as for the spurs.

Table 2. The Holdover Effects of Premature Defoliation in 1922 on the Production of Flowers and Fruit on Shoots in 1923.

	Defoliated	Not Defoliated
Number of shoots from which records were obtained	86	117
Average number of fruit buds per shoot, 1923	7.0	8.9
Average number of flowers per bud, 1923	2.1	2.7
Average number of flowers per shoot, 1923	15.3	24.9
Percentage of flowers maturing fruit, 1923	22.0	28.0
Average number of cherries harvested per shoot, 1923	3.4	7.1
Average weight per cherry (grams), 1923	3.1	3.5
Average weight of cherries per shoot (grams), 1923	11.0	25.0

It may be said, then, that defoliation caused significant and distinct differences in the performance of the trees. Prematurely defoliated trees produced fewer blossoms, the blossoms were poorly developed and slow in opening, fewer cherries ripened, the cherries were smaller in size and the total production per spur was only 42 per cent as great as on normal trees. It may be emphasized further that the total production per tree was still further reduced as 18 per cent of the spurs on prematurely defoliated trees died during the winter following the defoliation and were not considered in the records taken in 1923.

On Growth. Heavy production of fruit in the Montmorency cherry depends on several factors, one of which is the formation of new spurs. Spurs develop only from lateral leaf-buds and they are laid down in considerable numbers only on vigorous shoots; weak shoots usually bear only

Table 3. The Holdover Effects of Premature Defoliation in 1922 on Wood and Leaf Growth on Spurs in 1923.

	Defoliated	Not Defoliated
Number of spurs from which records were obtained	132	133
Average length of terminal growth (centimeters,) 1923	1.4	3.6
Average number of leaves per spur, 1923	5.1	5.9
Average size of leaves, (square centimeters), 1923	11.8	14.3
Average leaf area per spur (square centimeters), 1923	60.9	85.3

fruit-buds laterally, seldom leaf-buds. Spurs, once formed, must be kept in a vigorous condition or their growth will be smaller with a consequent reduced fruit production and plenty of healthy leaves are necessary to maintain this vigorous condition. Data given in Table 3 show the influence of defoliation in 1922 on the terminal growth, the number of leaves formed and the size of the leaves on spurs in 1923. In Table 4 similar data are presented for shoots.

Table 4. The Holdover Effects of Premature Defoliation in 1922 on Wood and Leaf Growth on Shoots in 1923.

	Defoliated	Not Defoliated
Number of shoots from which records were obtained	86	117
Average length of terminal growth on shoots (centimeters), 1923	6.8	14.5
Average number of leaves per shoot, 1923	8.8	10.3
Average size of leaves (square centimeters), 1923	16.6	18.3
Average leaf area per shoot (square centimeters), 1923	144.0	183.0
Average length of spur growth from lateral buds (centimeters), 1923	0.6	3.4
Average number of leaves per spur	4.2	6.3
Average leaf area per spur (square centimeters), 1923	41.5	85.6

On Spur Formation. In a preceding paragraph it has been pointed out that the development and maintenance of spurs is essential to maximum production and further that the original development of spurs depends on the presence of lateral leaf buds. It may be seen, then, that the number of

Table 5. The Effects of Premature Defoliation in 1922 on Spur Formation in 1923 and 1924.

	Defoliated	Not Defoliated
Number of shoots from which records were obtained, 1923	86	117
Average number of lateral leaf-buds on shoots, spring of 1923	1.8	2.0
Percentage of all buds that were leaf-buds, spring of 1923	20.0	18.0
Number of shoots from which records were obtained, 1924	229	425
Average number of lateral leaf-buds on shoots, spring of 1924	0.3	1.6
Percentage of all buds that were leaf-buds, spring of 1924	4.6	17.6
Average number of fruit buds on shoots, spring 1924	6.5	7.6

spurs which will develop in any given year may be fairly accurately predicted by determining the number of lateral leaf buds laid down during the previous summer. Data to show the influence of defoliation on this are presented in Table 5. The records for 1923 are from the shoots from which

data are presented in Tables 2 and 4 but in 1924 the records were obtained from shoots of all lengths selected at random on trees of both classes and the data are from 229 shoots on trees which were defoliated in 1922 and 425 on trees which were normal that year. Both classes of trees retained their foliage in a normal way in 1923. The length of all the shoots studied in 1924 was recorded so that it is possible to show the relation between the length of shoot growth (vigor) and the number of lateral leaf buds formed. These data are presented in Table 6.

Table 6. The Effect of Premature Defoliation in 1922 on Shoot Growth in 1923 and on the Relation between Shoot Growth and Lateral Leaf-bud Formation.

Length of Shoots (centimeters)		0 to 7.5	7.6 to 15	15.1 to 22.5	22.6 to 30
Percentage distribution of shoots. (According to length)	Defoliated.....	82	16	2	0
	Not defoliated...	30	44	23	3
Percentage of buds leaf-buds	Defoliated.....	4	7	15	—
	Not defoliated...	10	13	18	40

On Stored Foods. An effort was made to determine what effect defoliation might have on the amount of carbohydrates stored in the spurs and shoots of the cherry. Samples of shoots and spurs were collected in the spring of 1923 just as the buds were beginning to swell. The samples for analysis were collected from the one year old wood of shoots and from entire spurs. Determinations were also made of total nitrogen. The results of the analyses are given in Table 7 and are presented to explain, in part, at

Table 7. The Effects of Premature Defoliation in 1922 on Carbohydrate and Nitrogen Content of Spurs and Shoots in Spring of 1923.

Materials Determined by Analysis	Defoliated Per cent	Not Defoliated Per cent
Total sugars	0	2.52
Starch	1.06	1.48
Total sugars and starch	1.06	4.00
Polysaccharides	15.66	15.37
Total carbohydrates	15.66	17.89
Total Nitrogen	1.33	1.33

Methods of Preparation and Analysis. The material was cut into small pieces and placed in tared bottles and dried in an oven at 90 degrees C. to constant weight. It was then ground and analyzed for total sugars, starch, polysaccharides and total nitrogen. Total sugars were determined according to the A. O. A. C. method. Starch was determined according to the method of Walton and Coe (Determination of Starch Content in the Presence of Interfering Polysaccharides, In Jour. Agr. Research v. XXIII, No. 12, p. 995-1006, 1923.) The polysaccharides were determined according to the A. O. A. C. method for starch and include starch, the pentosans and other carbohydrate bodies which undergo hydrolysis and conversion into reducing sugars on boiling with hydrochloric acid. Total nitrogen determinations were made by the Gunning method.

least, the differences in production and growth in 1923 between trees which were prematurely defoliated in 1922 and those which were not.

The effects of defoliation on growth may be summarized in this way: terminal wood growth on both spurs and shoots was greatly reduced; the total leaf area per spur and per shoot was materially reduced; the growth of wood and leaves on newly formed spurs was seriously affected and the number of lateral leaf buds formed in 1923 was so reduced that relatively few new spurs could be produced in 1924.

Finally it may be said that defoliation results not only in decreased fruit production in the season following the defoliation, but what is probably more serious, it so affects the trees, by reducing spur development, that production will be lowered for an indefinite period.

THE CONTROL OF CHERRY LEAF-SPOT

There are two recognized methods of controlling cherry leaf-spot: (1) sanitary measures and (2) the use of fungicides in the form of sprays or dusts. The sanitary method of control consists of disposing of the source of infection which may be done by covering the old leaves on the ground under and near the trees. This is usually accomplished by plowing or discing the soil in early spring before any spore discharge has occurred. These measures are to be encouraged but are to be regarded only as supplementary to the proper use of a suitable fungicide.

Spraying and Dusting Experiments. The spraying experiments discussed in this report were carried on in 1922, 1923 and 1924. The work in 1922 and 1923 was done in the Titus Brothers' orchard near Traverse City and in 1924 in an orchard near Hart belonging to W. R. Roach and Company. The experiments in 1922 at Traverse City were in two orchards; one of Montmorency, eleven years old and one of English Morello, part of which was eleven years old and the remainder twenty-three years old. In 1923 the work was confined to the Montmorency orchard. The work at Hart in 1924 was in an orchard of Early Richmond, in which the trees were five years old. The soil in all the orchards is of a sandy type and cultivation was practiced throughout the early part of the season.

Materials and Schedules of Application. The more important requisites of a spraying material for cherry leaf-spot are: (1) that it shall control the disease, (2) that it shall not cause serious foliage injury and (3) that it shall not interfere with the proper development of the fruit. The one which most nearly meets all these requirements may be considered the most satisfactory for general use. The materials used in these experiments were lime-sulphur, and bordeaux sprays, sulphur, and copper dusts, and a few proprietary materials which were tested in comparison with the others. A detailed list of the materials used each year together with the strengths of the sprays and the formulae of the dusting mixtures is given in Table 8. The schedules and dates of applications are shown in Table 9. All spraying was done with power sprayers maintaining pressures of 200 to 225 pounds. Spray guns were used for the work at Traverse City and rods with nozzles at Hart.

All dusting was done with large, power dusters. The dusts were nearly always applied under very favorable conditions. The work at Traverse City was done in the late evening, during the night, or early in the morning, and at Hart only when there was very little or no wind blowing.

Table 8. Materials Used in Spraying and Dusting Experiments at Traverse City and Hart.

Traverse City		Hart
1922	1923	1924
Liquid lime-sulphur, 2 ½ gals. in 100.	Liquid lime-sulphur, 3 gals. in 100.	Liquid lime-sulphur, 2 ½ gals. in 100.
Bordeaux 8-14-100 (hydrated lime)	Bordeaux, 6-14-100 (hydrated lime)	Bordeaux, 6-10-100 (lump lime)
Copper dust—home mixed (20 % monohydrated copper sulphate)	Pryox, 18 lbs. in 100 gals.	Colloidal sulphur (Herbert and Herbert) 10 lbs. in 100 gals.
Copper dust — factory mixed, (20 % monohydrated copper sulphate)	Copper dust—factory mixed, (20 % monohydrated copper sulphate)	Copper dust—factory mixed, (20 % monohydrated copper sulphate)
Sulphur dust, 80-10-10	Sulphur dust, 90-10	Sulphur dust, 90-10
Check, no treatment	Check, no treatment	Check, no treatment

Lead arsenate powder was used in lime-sulphur, bordeaux and other spraying materials at the rate of two pounds in 100 gallons, and in the dusts in the proportion of 10 per cent by weight. It was not used in the special dust applications just before harvest nor in the after-harvest application in 1924.

Table 9. Schedules and Dates of Application.

Application	Traverse City		Hart
	1922	1923	1924
	Montmorency and English Morello	Montmorency	Early Richmond
Petal-Fall	May 23. Complete applications of both dusts and sprays.	June 4-5. Complete applications of both dusts and sprays.	June 10. Complete applications of dusts and sprays.
Two Weeks	June 6. Complete application of dusts and sprays.	June 18-19. Complete application of sprays. Dust applied to one side only of trees. Other side was dusted on June 11.	June 26. Complete applications of both dusts and sprays.
Four Weeks	June 20. Complete application of both dusts and sprays.	July 3. Complete application of sprays. Dusts applied to one side only. Other side of trees dusted June 25.	July 11. Complete applications of both dusts and sprays.
Special	July 6. No treatment on Montmorency. Dusts only on Morello.	July 10. No spraying. Dusts applied on one side only.	
After Harvest	Aug. 2. Complete application of both dusts and sprays. This was made after Morello harvest.	July 27. Complete application of dusts and sprays.	Aug. 5. Complete applications of dusts and sprays. Dusts were applied very heavily.

Dosage. The amounts of materials used per tree for Montmorency in 1922 and for Early Richmond in 1924 are shown in Table 10. The actual comparative cost of materials for dusting and spraying may be easily figured from this, using the prevailing prices for the various materials. Accurate labor costs cannot be obtained in connection with spraying and dusting work of this nature.

Table 10. Amounts of Dusting and Spraying Materials Used per Tree per Application.

Material	Montmorency 1922	Early Richmond 1924
Lime-sulphur	2.3 gals.	1.4 gals.
Bordeaux	1.8 gals.	1.4 gals.
Copper dust (commercial)	1.0 lb.	0.35 lb.
Sulphur dust	2.1 lbs.	0.58 lb.

Weather Conditions. The development of cherry leaf-spot depends on a liberal supply of moisture. Leaf-spot developed in epidemic form in 1922 and 1924, but was not generally serious in 1923. Rainfall was plentiful in 1922 and 1924 but there was relatively little in 1923. The daily record of precipitation for Traverse City in 1922 and 1923 and for Hart in 1924 is given in Table 11. A record of this kind does not indicate exactly how favorable conditions were for leaf-spot development since that is governed largely by the length of the period over which rain falls and to a certain extent by the time of day when it occurs. Temperature also plays an important part, particularly in the early part of the season. This table will, however, give a basis for comparing weather conditions in the three growing seasons. These records were obtained from the United States Weather Bureau Stations, four miles from the orchard at Traverse City and about three miles at Hart.

Leaf-Spot Development. Leaf-spot, as previously stated, did not develop seriously at Traverse City in 1923. There were no yellow leaves even on the check trees until September and then only in relatively small numbers. The disease did develop seriously in both 1922 and 1924, consequently any statements as to the comparative value of the various materials for the control of leaf-spot are based on the work of these two seasons.

In 1922 the epidemic came early in the summer and did not continue after the harvest period. Leaf-spot infection occurred very early and it could be seen on the leaves of both English Morello and Montmorency at the time of the petal-fall application (May 23). This early infection did not develop further, however, or cause any apparent injury. On June 6, leaf-spot was much in evidence on unsprayed English Morello trees but had not caused any defoliation. This infection undoubtedly occurred during the rains of May 24 and 25. By June 20, considerable defoliation had occurred on the English Morello checks, and leaf-spot was in evidence on the Montmorency checks. On July 7 the English Morello checks were heavily defoliated and the untreated Montmorency trees had lost about 60 per cent of their leaves. In connection with the leaf-spot present and the consequent defoliation noted on June 20 and July 7, it is interesting to note a prolonged period of rainfall on June 9, 10, 11 and 12, and one of

Table 11. Daily Rainfall at Traverse City, 1922 and 1923, and Hart 1924.

May	Traverse City		Hart	June	Traverse City		Hart	July	Traverse City		Hart
	1922	1923	1924		1922	1923	1924		1922	1923	1924
1	.....	.....	.....	1	.....	.....	.....	1	.....	.....	.....
2	.....	.....	.....	2	.....	.....	T	2	.....	.....	.....
3	.....	.....	.21	3	.....	.30	.....	3	.....	.....	.....
4	.....	.....	.....	4	.....	.....	.....	4	.....	.....	.....
5	.....	.....	.33	5	.....	.....	.....	5	.....	.....	.....
6	.80	.....	.....	6	.....	.....	.....	6	.....	.....	.....
7	.40	.....	.17	7	.....	.80	.....	7	.22	.73	.78
8	.....	.01	.11	8	.....	.....	.....	8	.....	.....	.02
9	.50	.....	.28	9	.80	.....	.01	9	.....	.15	1.14
10	.....	.....	.01	10	1.12	.....	.....	10	.97	.....	.....
11	T	.....	.....	11	.12	.....	.....	11	.....	.....	.....
12	.....	.....	.....	12	.02	.....	.02	12	.52	.....	.....
13	.....	.....	.06	13	.....	.....	.18	13	.....	.....	.....
14	.....	.....	.....	14	.....	.....	.....	14	.....	.57	.....
15	.....	.70	.02	15	.....	.....	.60	15	.....	.....	.....
16	.....	.01	.....	16	.....	.....	.....	16	.....	.....	.07
17	.10	.....	.03	17	.25	.....	.....	17	.12	.....	.....
18	.....	.....	.....	18	.27	.....	.11	18	.....	.....	.....
19	.80	.....	.05	19	.....	.01	.....	19	.....	.....	.....
20	.....	.60	.....	20	.....	.....	.09	20	.....	.....	.....
21	.....	.....	.....	21	.....	.....	.....	21	.....	.....	.....
22	.....	.....	.12	22	.....	.....	.....	22	.....	.....	1.07
23	.....	.....	.46	23	.....	.....	.24	23	.....	.80	.....
24	.40	.....	.09	24	.....	.....	.02	24	.....	.....	.71
25	.60	.....	.02	25	.....	.....	.04	25	.....	.....	.....
26	.....	.....	.....	26	.....	.....	.....	26	.....	.....	.....
27	.....	.....	.04	27	.....	.....	.....	27	.....	.....	.....
28	.....	.....	.....	28	.....	.....	.06	28	.....	.....	.....
29	.....	.....	.....	29	.....	.....	.03	29	.....	.22	.02
30	.....	.....	.....	30	.....	.....	.01	30	.....	.....	.....
31	.40	.....	T	.....	.....	.....	.....	31	.52	.....	T

shorter duration on June 17 and 18. Montmorency cherries were ripe July 17 on trees which were not badly defoliated, but the check trees had been so badly defoliated that the fruit did not mature. English Morello ripened somewhat later but the fruit from unsprayed trees was never harvested and several of the check trees died before the next growing season. A small amount of defoliation occurred on Montmorency during the harvest period so that the trees were almost completely defoliated by August 1.

In 1924 weather conditions were such that leaf-spot did not develop seriously at Hart until the harvest period and defoliation continued from then until early September. It was first seen on check trees on July 11 but no defoliation had occurred at that time; by July 26, however, they had lost some leaves. The heaviest fall of foliage occurred during August and early September and unsprayed trees were almost completely defoliated at the latter period.

The point to be emphasized most in connection with these statements of leaf-spot occurrence is that any noticeable development of leaf-spot was always immediately preceded by a period of rainfall.

Comparative Value of Spraying and Dusting Materials for the Control of Leaf-Spot. The materials used showed a wide range of effectiveness in the control of leaf-spot. Some materials were very unsatisfactory, some gave a moderate degree of control and others practically complete control.

Bordeaux. Very satisfactory results were obtained with bordeaux in all experiments. In 1922 it gave practically complete control on Montmorency and very good results on English Morello although leaf-spot developed slightly more on this variety with bordeaux than with lime-sulphur. In 1924, with Early Richmond at Hart, the control was practically complete.

Lime-sulphur. This material gave almost complete control in 1922 on Montmorency and slightly better results on English Morello than did bordeaux. The difference was very slight and leaf-spot developed only to a very limited extent with either. With Early Richmond at Hart in 1924 lime-sulphur gave satisfactory results although the control was not as complete as with bordeaux.

Pyrox and Colloidal Sulphur. No statement can be made as to the fungicidal value of Pyrox as this material was used in 1923 when leaf-spot did not develop. Colloidal sulphur gave unsatisfactory control of leaf-spot. The trees sprayed with this material were in much better condition than the checks but the results were unsatisfactory when compared with lime-sulphur or bordeaux.

Sulphur and Copper Dusts. The control of leaf-spot by the use of dusts has not compared favorably with that obtained by the use of lime-sulphur or bordeaux. There has been some difference in the effectiveness of the two kinds of dust. In 1922 at Traverse City, Montmorency trees treated with copper dust (20 per cent) lost about 25 per cent of their leaves and those treated with sulphur dust (80-10-10) approximately 75 per cent. With English Morello, both dusts gave better control than on Montmorency but the copper dust was again more effective than the sulphur. The better control with dusts on English Morello was due probably to the extra application just before harvest; this was not made on the Montmorency trees. There was no apparent difference of any sort in the effectiveness of the commercial and home-mixed copper dusts. At Hart, in 1924, leaf-spot developed rather seriously in both dusted plots, and again sulphur dust was less effective than copper dust. The difference in the effectiveness of the two dusts was not so great as in 1922. This may have been due to difference in the composition of the sulphur dust. It was of 80-10-10 composition in 1922, and 90-10 in 1924; the 80-10-10 dust contained 10 per cent of hydrated lime and consequently 10 per cent less of sulphur.

Foliage Injury and Dwarfing of the Fruit.* There were distinct differences with various materials, in the amount of injury to foliage and in the size of the cherries. Most of the observations on foliage injury were made in 1923 at Traverse City, and at Hart in 1924. In 1922 there was practically none to be observed. In making any general statement regarding foliage injury, the results of earlier experiments already published are considered as well as other recent experiments which are not yet reported. Observations on the effects of spraying and dusting materials on the size of cherries are for four years, beginning in 1921. A general statement of results follows:

Pyrox caused very severe foliage injury and defoliation, the trees losing over half their leaves. **Colloidal sulphur** caused no apparent injury to the foliage. Neither **sulphur** nor **copper dust** has caused foliage injury at any time, and caused only a very slight reduction in the size of the cherries. **Bordeaux** has caused severe foliage injury in many instances and has also seriously reduced the size of the fruit. This dwarfing effect has been most severe in seasons of relatively light rainfall. **Lime-sulphur** has caused very little foliage injury and only a slight dwarfing of the fruit.

EFFECTS OF CHANGING FROM LIME-SULPHUR TO BORDEAUX OR VICE VERSA

Some growers have preferred to use bordeaux because of its excellent fungicidal properties, but, because of the dwarfing effect on the fruit, have substituted lime-sulphur for all or part of the applications before harvest and then made the after-harvest application with bordeaux. Such practice, in 1923, resulted, in nearly every instance, in serious foliage injury. Reports of such injury were received from nearly all cherry growing districts. In experiments at Traverse City, which are not reported in detail in this paper, the materials were alternated in various ways; from lime-sulphur to bordeaux and from bordeaux to lime-sulphur. The changes were made at different applications but the result was always the same;—severe foliage injury followed, regardless of which way the change was made or at what period it occurred. Such changes have been made in other years without apparent ill-effects but because of the possible serious results which may follow under some conditions, the practice must be considered unsafe.

*Complete reports of the work on foliage injury and on the effects of spraying materials on the size of cherries will be made in other publications to be issued later.

SUMMARY

Residual or Holdover Effects of Premature Defoliation by Leaf-Spot. Heavy, premature defoliation caused significant reductions in yield and growth. Trees which had been defoliated the year previous, produced relatively few blossoms and these blossoms were small and opened slowly. Fewer cherries ripened; they were smaller and the total production per spur was reduced seriously. The vigor of defoliated trees was lowered as shown by reduced wood growth on old and new spurs and on shoots, by smaller leaves and by a serious reduction in the formation of new spurs as evidenced by the relatively small number of lateral leaf buds developed.

Comparative Value of Spraying and Dusting Materials. The results obtained from the use of different materials varied widely in regard to fungicidal value, foliage injury and effect on the development of the fruit.

Pyrox cannot be recommended for use on cherries because of the serious foliage injury which may follow its use.

Colloidal sulphur did not cause any foliage injury but gave unsatisfactory control of leaf-spot.

Sulphur and copper dusts have caused no foliage injury and their use has not resulted in any serious reduction in the size of the fruit, but they have not given satisfactory control of leaf-spot in seasons when conditions were favorable for its development.

Bordeaux has produced consistently satisfactory control of leaf-spot but it has frequently caused severe foliage injury and serious reduction in the size of the fruit.

Lime-sulphur also has given satisfactory control of leaf-spot; it has not caused any foliage injury of consequence and its use has not seriously reduced the size of the fruit. This material has most satisfactorily met the requirements and it may be expected to give satisfactory results if it is properly used.

Changing from lime-sulphur to bordeaux or from bordeaux to lime-sulphur during the same season may cause serious foliage injury and such practice should be considered unsafe.

Recommendations. The results of the experiments reported in this bulletin and of observations made in connection with other experimental and commercial spraying justify the recommendation that liquid lime-sulphur, diluted at the rate of 3 gallons in 100, should be used in Michigan for the control of leaf-spot on sour cherries.

Four applications, according to the following schedule should be made.

1. Just after the petals have dropped.
2. Two weeks after petal-fall.
3. Four weeks after petal-fall.
4. Just after harvest.

Lead arsenate, 2 pounds or more in each 100 gallons of diluted spraying material, should be used in all applications.

Acknowledgments. The authors are indebted to Titus Brothers and to John Barr of Traverse City and to the W. R. Roach Co. at Hart for the hearty co-operation given in connection with the work; to Professors V. R. Gardner and F. C. Bradford for many valuable suggestions; to Professor R. E. Loree for making chemical analysis of the spurs and shoots; and to Dr. G. H. Coons and Mr. C. W. Bennett for much valuable information regarding the development and identification of leaf-spot. The determinations of nitrogen in the spurs and shoots were made under the direction of Professor A. J. Patten.

ROBERT SMITH COMPANY
LANSING, MICH.